The Government Game Behaviour in the Process of Protecting the Patented Products

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Abstract—**In the economic field, there are game relationships among central government, local government and the enterprises, which come from different interest groups who try to make their own interest maximum. When one enterprise engages in R&D activities and is infringed, there exist non-cooperative game relationships between the central government and local government, and the game eventually will affect the central government policies, while the central government decisions also affect the entire market and local government strategy. This paper focuses on the government game behaviour in the process of protecting the patented products, and attempts to analyze the business conditions and its economic environment by using Principles of Microeconomics and Game Theory, so as to find out the factors that ultimately influence the government policy-making and how the government policies affect enterprises.**

Keywords—patented products protection; Quartet Game; enterprises; government behaviour

I. INTRODUCTION

There are multiple sources of uncertainty in R&D investment projects and their uncertainties interactions in complicated ways, so that the standard analysis of real options theory can not share the project investment decisions, then Game theory is introduced to in the framework of real options theory by more and more domestic and foreign scholars. According to Fudenberg and Tirole (2003), Myerson (2001) and Smit (2006), Game theory is to study the behaviour of multiple interacting decision-making body when the decision-making and balance theory.

Smets (1991)[1] is the first article to study game model under uncertainty symmetrical duopoly option, which combine the real options approach with the traditional game model, is the basis for continuous-time option game. Dixit and Pindyck (1994) [2] summary the model and give a mathematical proof to solve the optimal investment timing and benefits of the leader and followers. Lambrecht and Perraudin (1999) concentrate on preemption in winner-takes-it-all competitive investment games. By assuming that the two companies have been initially introduced in the market activities, Huisman, Thijssen, and Kort (2001) [3] introduce the concept of mixed strategy equilibrium. Smit and Trigeorgis (2004) [4] apply the discrete time option game method to analyse R&D investment strategy by taking account into the market, technology, information, competition and other factors, but do not give specific symmetric duopoly analysis of corporate investment strategy.

On the other hand, because of Property of Public Products, technology innovation and business results are difficult to be monopolized; there is a certain degree of spill-over effects. Kultti and Takalo (1998) [5] show that R&D Spillovers can be interpreted in a sense that even without spill-over firms have an incentive to exchange the R&D information after the investment costs are sunk. However, patent protection of new technologies can be seen as the legal effect of pure knowledge spillover made by the government, because spillover effects can be artificially developed, the study of patent protection has its special importance. Patent protection is generally manifested in reality within a certain period of time, and protection of innovations can only be enjoyed by the developers, while others have no right to use the same or somewhat similar innovations.

Weeds (2002) [6] have studied with an uncertain return of two competing irreversible investment project problems in the context of patent protection indefinitely. In addition, a number of related papers have studied patent protection. Baecker (2007) [7] Motchenkova (2008) [8], Sengupta (2009) [9], Harrigan, Mike Dixon (2010) [10], Mouallem (2010) [11] and Donal Loftus (2011) [12] have all analysed the patent protection problem from the aspects of government policies and legal system, which provide a reference for this paper.

At present, China is in an important period when are building market economy and the central government policies will directly affect the success or failure of market economy. In a market economy, there are a multi-game relationships among the central government, local government, and businesses, including central and local government, government and business, business to business. The game eventually will affect the central government policies, while the central government decisions also affect the entire market and local government strategy. However, in microeconomics, the market states of enterprises include monopoly, oligopoly and perfect competition, and so on.

Each state of enterprise has the best production and pricing strategy, and the optimal strategy can be obtained by analysing the environment. The central government reflect the will of the country; the strategy is more universal, which manage the entire market through legislative and administrative measures. As a direct marketing manager, local governments play an important role for regulating market. After the patented products enter market, the different game sides benefit from different options. In this paper, based on game theory, we try to get how the market factors affect the central government decision-making by analysing how the benefits of enterprises affect the process of the benefits of government.

The article is organized as follows. Section 2 explains the relationships among enterprises, local and central government after the patented product enter market. Section 3 presents the benefits of government after the *A* company was infringed. Section 4 describes the important factor which affect the

central government policy by analysing the four-game. Finally, Section 5 concludes the article and provides some remarks.

II. THE RELATIONSHIPS AMONG THREE AFTER PATENTED PRODUCT ENTER MARKET

A. Business to business relationship

Assume that there are two films in the market, *A* and *B*. *A* engages in R&D activities and chooses whether to enter market, but *B* is not and choose whether to fake the product of *A*. There are three cases in the market between *A* and *B*: (1) *A* film monopoly. When *A* engages in R&D activities and enters market, *B* is no fake, where *A* will monopolize the market. (2) *A* and *B* films common monopoly. When *A* enters market, and *B* imitates its products, where will result in the emergence of two films, namely duopoly. (3) *B* film monopoly. When *A* experiences losses resulting from infringement, and not to be stopped. When *A* exits the market in order to reduce loss, then *B* monopolizes the market.

1) A film monopoly

Assuming the product demand function of *A* is

$$Q = a_1 - b_1 P \qquad (1)$$

Average revenue *AR* is equal to product price *P*, so that monopolist curve *AR* and demand curve *d* always overlap, monopolists meet short-term equilibrium, following $MRA = MCA$. A short term profit of *A* is

$$A_1 = (P_1 - c_1) * Q_1 \qquad (2)$$

Where A_1 is monopoly profit of *A*, P_1 is monopoly price of *A*, c_1 is the cost of *A*, Q_1 is product needs of *A*.

2) A and B films duopoly

This is a Bertrand oligopoly model. Assume product demand function of *A* and *B* films are

$$q_1 = q_1(P_1, P_2) = a_1 - b_1 P_1 + d_1 P_2 \qquad (3)$$
$$q_2 = q_2(P_1, P_2) = a_2 - b_2 P_2 + d_2 P_1$$

The profits of *A* and *B* films are respectively：

$$A_2 = (P_1 - c_1)q_1 = (P_1 - c_1)(a_1 - b_1 P_1 + d_1 P_2) \qquad (4)$$
$$B_2 = (P_2 - c_2)q_2 = (P_2 - c_2)(a_2 - b_2 P_2 + d_2 P_1)$$

Where c_1, c_2 denote costs of *A* and *B* films respectively.

There is a brand difference between *A* and *B* films which makes the product prices different, but because of the nature of product remains unchanged, therefore *A* and *B* films exist product substitution effects, where d_1, d_2 denote substitution rates respectively. b_1, b_2 denote the degree of output sensitivity to price of *A* and *B* films respectively. a_1, a_2 is market factor of *A* and *B* films demand respectively.

According to $\frac{\partial A_2}{\partial P_1} = 0, \frac{\partial B_2}{\partial P_2} = 0$, equilibrium price of *A* and *B* films are respectively：

$$P_1^* = \frac{d_1(a_2 + b_2 c_2) + 2b_2(a_1 + b_1 c_1)}{4b_1 b_2 - d_1 d_2}$$
$$P_2^* = \frac{d_2(a_1 + b_1 c_1) + 2b_1(a_2 + b_2 c_2)}{4b_1 b_2 - d_1 d_2} \qquad (5)$$

After substituting equation (3), (5) into (4), A_2 and B_2, equilibrium price of *A* and *B* films can be obtained.

3) B film monopoly

Assuming *B* and *A* film have similar situation, then the profit of *B* film is

$$B_1 = (P_2 - c_2) * Q_2 \qquad (6)$$

B. The Central Government to Local Government Relationship

The central government and local government constitute a principal-agent relationship in governing the country jointly. The central government are the client position, the local government in the agent position. Central and local government are essentially interests. As two different interest groups, each focuses on different interests. However as the country supreme ruler, the central government are pursuing to maximize the interests of society as a whole, while local government are seeking to maximize short-term interest areas.

There exist non-cooperative game relationships between the central government and local government. If local infringing enterprises will acquire a large number of benefits, which make a substantial growth in local GDP, but not necessarily in line with long-term national interests, then between the two are non-cooperative games.

C. Government to Business Relationship

As the main body of market economy, only profitable enterprises can bring benefits to the government, but only in the case of profitable enterprises will enter the market. Besides, when government in formulating and implementing policies, whether or not it is good for enterprise is the root cause of the vitality of enterprises in this region. In a long time, government interests are in line with interests of companies in the market, but not with every enterprise interest. Government are pursuing to maximize the interests of society, when in the development and implementation of policies, the central government are pursuing to maximize the benefits of overall social companies, but local government are more seeking to maximize the benefits of local companies.

III. THE GOVERNMENT BENEFITS IN DIFFERENT CIRCUMSTANCES

A. Benefit of Local Government

Because there are three different conditions between *A* and *B* film, therefore before and after *A* has been infringed, there are four conditions with the local government: (1) *A* film monopoly; (2) When *A* experiences infringement form *B*, and not to be stopped, but *A* can still acquire benefits, then *A* does not exit the market; (3) When *A* experiences loss resulting from infringement, then *A* exits the market; (4) When *A* experiences loss resulting from infringement, but is stopped by the court.

Local government are seeking to short-term interests of their terms of 5 years. After 5 years, promotion of local government officials are directly related to the performance, therefore local government are more of a pursuit of maximizing short-term business interests, and not a single enterprise long-term growth. Taking into account the time value of capital i, by assuming that government are seeking to maximize the benefit of five years, where α denotes the ratio of return on local government , M denotes when the central government assessment of local government, local government are punished for violations.

1) A film monopoly

$$D_1 = \alpha A_1 * PVIFA_{i,5} \qquad (7)$$

Where aA_1 denotes the benefit of the local government every year.

2) A and B film duopoly

$$D_{21} = \alpha(A_2 + B_2) * PVIFA_{i,5} \qquad (8)$$

3) A film by the B infringement, then exit

$$D_{22} = \alpha(A_2 + B_2) PVIFA_{i,t} + \alpha B_1 * (PVIFA_{i,5} - PVIFA_{i,t}) \qquad (9)$$

Where the first part is the benefits of local government when in duopoly; the second part is the benefits of government when A exits and B monopolies.

4) A film by the B infringement, but is stopped

$$D_{23} = \alpha(A_2 + B_2) * PVIFA_{i,t} + \alpha A_1 * (PVIFA_{i,5} - PVIFA_{i,t}) - M \qquad (10)$$

Where the first part is the benefits of local government when in duopoly; the second part is A acquire benefits after the violations are stopped by the court; finally, local government are punished due to poor performance.

B. Benefit of Central Government

Similar to the local government, there are four conditions with the central government. The central government are seeking to maximize long-term interests, eliminate low-tech companies through the collection of royalties, and protect the growing company. Where E denotes the fees of patent protection charged by government, β denotes the ratio of return on local governments, g denotes the investment growth ratio of A.

1) A film monopoly

$$Z_1 = \beta \frac{A_1(1+g)}{i-g} + \frac{E}{i} \qquad (11)$$

Assuming $i > g$, according to the Gordon growth equation, we can get the present value of film value, the first part is the benefit of the central government; the second part is the present value of patent costs.

2) A and B film duopoly

$$Z_{21} = [\beta(A_2 + B_2) + E]/i \qquad (12)$$

B acquires benefits by free rider, if A intends to do R&D activities which will inevitably lead to increasing costs, then A has no R&D initiative; therefore both films can not achieve sustained growth when in duopoly. The benefits of central government come from the duopoly profits and patents costs.

3) A company by the B infringement, then exit

$$Z_{22} = \beta(A_2 + B_2 + E) PVIFA_{i,t} + \beta B_1 / i \qquad (13)$$

Where the first part is the benefits of central government when in duopoly; the second part is the benefits of central government when B monopoly.

4) A film by the B infringement, but is stopped

$$Z_{23} = \beta(A_2 + B_2) PVIFA_{i,t} + \beta \left[\frac{A_1(1+g)}{(i-g)} - A_1 * PVIFA_{i,t} \right] + \frac{E}{i} \qquad (14)$$

Where the first part is the benefits of central government when in duopoly; the second part is that when A receives the government support and does R&D activities with confidence and continues to maintain the growth rate g, the present value of benefits calculated by the Gordon growth equation reduce to infringement within the recalculation part; finally is the present value of patent costs.

IV. FOUR-GAME PROCESS

A first makes decision, Z is the final decision. Calculating each node ($S1, S2, S3, S4, S5$), and the benefits of A, B, D and Z. With the symbols A_{S1} at the nodes $S1$ is the benefit of A, the other and so on. However, because A faces infringement of B that may lead to loss of A, we should discuss the game in different situations. There are a dynamic game among A B, D and Z, as shown in Fig.1.
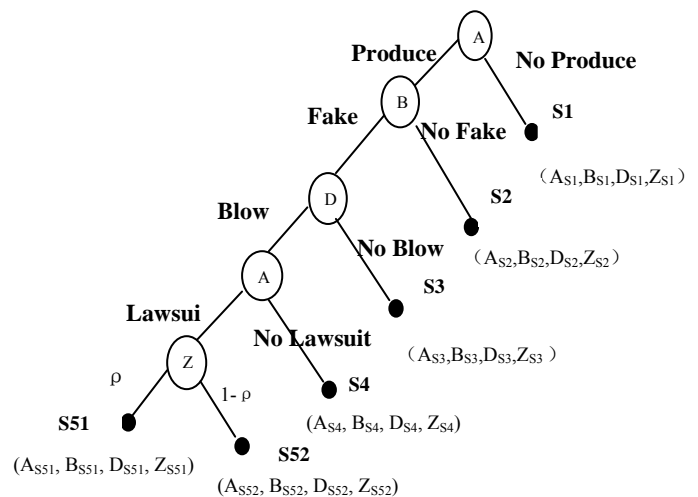

Fig. 1 four-game process in patent protecting

A. A Film Will Not Withdraw From the Market

$P_1^* > c_1$, that is $A_2 > 0$. When A film experiences infringement form B, and not to be stopped, but A can still

acquire benefits, then A does not exit the market, we analyse it using Backward induction.

1) The fourth phase

Where A is decision-makers which face litigation or non-litigation, but litigation with uncertainty, therefore the benefits of all parties can only be calculated by expectations. Suppose ρ is the winning probability of A; N is the number of winning compensation; H is litigation costs of A, B, respectively.

The benefit of A when choosing litigation is

$$A_{S5}=\rho\left[\frac{A_1(1+g)}{i-g}+N\right]+(1\text{-}\rho)\frac{A_2}{i}-E-H \quad (15)$$

Where the first part is the benefit of A when winning the litigation, the second part is the benefit of A when losing the litigation, and the third part is the payment royalties of A, and finally is the costs. Similarly, we can acquire the benefits of B, D and Z.

$$B_{S5}=(1-\rho)B_2/i-\rho*N-H$$
$$D_{S5}=\rho D_{23}+(1-\rho)D_{21} \quad (16)$$
$$Z_{S5}=\rho Z_{23}+(1-\rho)Z_{21}$$

The benefits of all parties when A chooses to give up litigation are

$$A_{S4}=A_2/i-E, \quad B_{S4}=B_2/i$$
$$D_{S4}=D_{21}, \quad Z_{S4}=Z_{21} \quad (17)$$

When $A_{S5}>A_{S4}$, A chooses a lawsuit, which is the last choice, but there are many factors affecting the expected payoff, such as A_1, ρ, N, H. One of the most critical factors is ρ, because at this time Z and A are the community of interests. If $Z_{S5}<Z_{S4}$, when Z in making decisions, who will make ρ decrease, so that A chooses to give up lawsuit, then Z will have a decisive impact on A. The important factors which will affect A choosing a lawsuit are a_1, b_1, c_1, d_1, and so on. Therefore only the profitability of A is strong enough which make Z has to protect A when in making decisions.

2) The third phase

Where D is decision-makers, whether or not the violations can be developed into the fourth phase, we should compare the benefit of D in different cases.

The benefits of all parties when D chooses to give up litigation are

$$A_{S3}=A_1/i-E, \quad B_{S3}=B_2$$
$$D_{S3}=D_{23}+M, \quad Z_{S3}=Z_{23} \quad (18)$$

When $D_{S3}>D_{S4}$, $D_{S3}>D_{S5}$, D will take severely crack down on violations. Otherwise, D will be in accordance with national policy to decide against infringement. When the central government take strict measures to protect intellectual property rights, ρ becomes large, so that A chooses a lawsuit, as well as the ultimate benefit of D.

$$D_{S5}=\rho[\alpha(A_2+B_2)*PVIFA_{i,t}$$
$$+\alpha A_1*(PVIFA_{i,5}\text{-}PVIFA_{i,t})-M] \quad (19)$$
$$+(1-\rho)\alpha(A_2+B_2)*PVIFA_{i,5}$$

Where A, B and M are related to the benefit of D. If the central government want to make local government regulation when carrying out due diligence, we must increase M, forcing local government to select the D_{S3}.

3) The second phase

The benefits of all parties when B chooses to give up infringement are

$$A_{S2}=A_1/i, \quad B_{S2}=0, \quad D_{S2}=D_1, \quad Z_{S4}=Z_1 \quad (20)$$

Where B is decision-makers, the benefit of B will become zero when B chooses to give up infringement. Therefore B does not make the infringement only when the benefit of B in the infringement is less than zero, then when the central government in supporting the protection of intellectual property, they will make strict laws, and increase M of local government. According to maximize their own interests, the central government decide the degree of ρ, N and M. Therefore, the strategy of the central government play a decisive role for when A, B and D exit the game.

4) The first phase

The benefits of all parties when A chooses not to enter market are

$$A_{S1}=0, \quad B_{S1}=0, \quad D_{S1}=0, \quad Z_{S1}=0 \quad (21)$$

Where B is decision-makers, if A chooses not to enter market, the benefits of all parties are zero, but it is invalid. Because the next game process will make the benefit of A greater than zero, then A will not choose S_1. Therefore, the strategy of central government (ρ, M, N, E) will affect all parties from the stage2-5 of the game, and ultimately a, b, c, d, g, i are factors which affect the central government policy.

The analysis has several implications. First, the size of the domestic market, domestic and foreign enterprises competitiveness, the domestic market, the average level of profitability, the company growth and other factors directly affect the strategy of the central government. Secondly, the integrity of national law, the degree of penalties for violations and local government supervision, the costs imposed on business directly affect the behaviour of enterprises, which can attract more foreign businesses and promote business innovation activities. Through different strategies, Government regulate market competition and ultimately optimize the market structure.

B. A Company Will Withdraw from the Market

$P_1*<c_1$, that is $A_2<0$, When A experiences losses form infringement, then A chooses to exit the market, we also analyse it using Backward induction.

1) The fourth phase

The benefits of all parties when A chooses litigation are

$$A_{S5}=\rho\left[\frac{A_1(1+g)}{i-g}+N\right]+(1-\rho)A_2/i-E-H \quad (22)$$
$$B_{S5}=(1-\rho)B_1/i-\rho*N-H$$
$$D_{S5}=\rho D_{23}+(1-\rho)D_{22}$$
$$Z_{S5}=\rho Z_{23}+(1-\rho)Z_{22}$$

The benefits of all parties when *A* chooses to give up litigation are

$$A_{S4}=A_2 , \quad B_{S4}=B_1/i , \quad D_{S4}=D_{22} , \quad Z_{S4}=Z_{22} \quad (23)$$

Assume $A_{S5}>A_{S4}$，then *A* will acquire the protect by law, otherwise it is will exit the market. If *A* exits the market, then the benefits of local government will be less than *A* in the market, which is $D_{S4}<D_{S3}$.Therefore the local government will choose strictly against infringement in the third phase.

2) The third phase

The benefits of all parties when *D* chooses strictly against infringement are

$$A_{S3}=A_1/i-E , \quad B_{S3}=B_2$$
$$D_{S3}=D_{23}+M , \quad Z_{S4}=Z_{23} \quad (24)$$

The local government makes decision when in maximizing the benefits:

$$D_{S4}=\alpha(A_2+B_2)*PVIFA_{i,t}+\alpha B_1*(PVIFA_{i,5}-PVIFA_{i,t})$$
$$D_{S3}=\alpha(A_2+B_2)*PVIFA_{i,t}+\alpha A_1*(PVIFA_{i,5}-PVIFA_{i,t}) \quad (25)$$

A_2 and B_2 which ultimately affect the local government decision-making, denote the protection of local governments can bring short-term interests for enterprise in monopoly.

3) The second phase

The benefits of all parties when *B* chooses to give up infringement are

$$A_{S2}=A_1/i , \quad B_{S2}=0 , \quad D_{S2}=D_1 , \quad Z_{S4}=Z_1 \quad (26)$$

Similarly, whether or not to fake *A* product depends on the expectation of *B* and the degree of local government protections. If $B_2>A_2$, *B* can acquire local government protections. Even more, if the local government condone infringement, *A* ultimately will choose not to enter the market in the first phase.

4) The first phase

The benefits of all parties when *A* chooses not to enter market are

$$A_{S1}=0 , \quad B_{S1}=0 , \quad D_{S1}=0 , \quad Z_{S1}=0 \quad (27)$$

When in duopoly, the cost of *A* is greater than price, and exists loss. If there is no corresponding legal protection and local government don't strictly crack down on infringement, then *A* will choose not enter the market in the first phase, and ultimately the benefits of all parties are zero. Therefore, in order to avoid it, the central government can adjust *ρ* which makes the R&D enterprise acquire benefits and continues to do

R&D activities, or regulate *M* which makes local governments to increase efforts to investigate violations.

V. CONCLUSION

This paper has studied the patent protection problem and shown for quite reasonable parameters that the patent protection considerations are important. In particular, the central government filter the potential profitability of intellectual property by adjusting *M* to regulate local government behaviour, *N* to punish infringing films, *E* to screen the market profitability of intellectual property, and *ρ* to the interests of various social groups, thereby ensuring the maximization of national interests. When making policy, we must assure that the protection measures are not so strictly that benefits will be reduced, and note that sub-damage the interests of R&D films will make them exit the market. The formulation of laws and different approaches of the local government can make economic development, that is upholding the law of the universality and flexibility of local government is essential.

Because there are different states of enterprises, mainly showing through the business parameters *a, b, d*. The stronger enterprises which owe market potential product generally have a high a. High profile and reputation of enterprises generally have a small *b* and large *d*. Therefore, the equilibrium price and equilibrium profits are different in all types of enterprises. However, for large enterprises, the final equilibrium profits of high profile enterprises are likely positive; but for emerging enterprises, the high R&D investment will result in increasing *c*. If the central government and local government take no corresponding protection measures, eventually they will exit the market. But relative to the central government, local government pay more attention to short-term interests, local government tend to protect enterprises which can bring a lot of short-term interests, and ignore those which engage in R&D activities with the development prospects but can't bring a lot of short-term interests. Therefore, the negative way of local government could lead lack of innovative enterprises. In order to ensure maximum benefits of society, the central government should pay more attention to protection of innovation-oriented enterprises, and avoiding excessive pursuit of short-term interests which lead to the future interests becoming zero.

Because of the high cost of legal rights, small businesses are generally difficult to enter the final stage. For no growth businesses, the central government make them exit the market by adjusting *ρ, M, N, E*; for growth businesses, the central government make them acquire protection of local governments by adjusting *ρ, M, N, E*; but for large enterprises, because the central government and big businesses are community of interests, the central government have considered their interests when making laws.

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